A.C. Millivoltmeter VM78

Instruction Manual

ADVANCE

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Instruction Manual

ADVANCE ELECTRONICS LIMITED
INSTRUMENT DIVISION
ROEBUCK ROAD, HAINAULT, ILFORD, ESSEX, ENGLAND
TELEPHONE 01-500 1000 TELEGRAMS ATTENUATE, ILFORD

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This high grade instrument has 12 overlapping ranges from 1mV f.s.d. to 300V f.s.d. The accuracy is $\pm 3\%$ f.s.d. over the frequency range of 1 Hz to 1 MHz, and the input impedance is 2M Ω shunted by 60pF.

The meter scale is calibrated in r.m.s. volts of a sine wave; 0 to 1 and 0 to 3, and in level measurements from −12dB to +2dB where 0dB being equivalent to 1mV in 600 Ω.

The VM78 consists of three main sections; a high input impedance stage, a two section attenuator and a directly coupled amplifier which feeds the meter via the retifier circuit. Mercury cells are used to power the instrument, giving long life and absence of hum which, together with the low noise design allows very small voltages to be measured.

Great care has been taken in protecting the instrument against damage from the application of an incorrectly high input voltage, and the instrument has been designed for the wide temperature range of 0 to 45°C.

Voltage Ranges

F.S.D.		*Attenuator Settings*	
0.001V	1V	−60dBm	0dBm
0.003V	3V	−50 ,,	+10 ,,
0.01V	10V	−40 ,,	+20 ,,
0.03V	30V	−30 ,,	+30 ,,
0.1V	100V	−20 ,,	+40 ,,
0.3V	300V	−10 ,,	+50 ,,

Frequency Range
1 Hz to 1 MHz

Accuracy
±3% f.s.d.

Typical Input Impedance
2M Ω shunted by 60pF.

Overload Protection
Protected for inputs up to 400V peak on 0.3V and higher ranges, and for 100V r.m.s. on 0.1V and lower ranges.

Power Supply
Battery operation only.
Two mercury cells Mallory Type TR-233R.
Three mercury cells Mallory Type RM-3.
Battery life approximately 350 hours.

Temperature Range
0 to +45°C.

Noise
Typically less than 50μV referred to the input when terminated in 47k Ω on the 0.001V range. Residual reading less than 3% of f.s.d. on all other ranges.

Residual Reading
Less than 3% f.s.d. on ranges other than 0.001V f.s.d.

Turn-on Time
High frequency position requires 20 secs.
Low frequency position requires 50 secs.

Accessories
A shielded lead type PL50 is supplied with the VM78 and has a nominal input capacity of 60pF.

Dimensions

Width	*Height*	*Depth*
$8\frac{7}{8}$ in	$6\frac{1}{2}$ in	$5\frac{1}{2}$ in
(22.5 cm)	(16.5 cm)	(14 cm)

Weight
6 lb 10 oz (3 kg).

Finish
Dark blue metal case with light grey front panel and medium grey surround.

3.1 FUNCTION SWITCH

Check the battery by rotating switch to the BAT. TEST position. The meter should read above 7V on the 0 to 1 meter scale. If there is no reading or the reading is low, refer to MAINTENANCE, Section 5.

Select the required frequency response. In general the switch will be used in the 15 Hz to 1 MHz position, to avoid the longer time constants of the 1 Hz to 1 MHz position.

3.2 RANGE SWITCH

Where possible select a range which will give a reading in the upper two thirds of the meter scale. This will ensure that the accuracy of the instrument is fully utilised.

It is good practice to always switch the instrument to a high voltage range before applying external voltages, and then select a range which will allow the external voltage to fall on the upper two thirds of the meter scale. This is particularly the case where measurements of small amounts of ripple are being made, superimposed on a high d.c. potential.

The instrument is protected for a maximum peak voltage of 400V on ranges 0.3V and above, and for 100V r.m.s. on 0.1V and below. There is d.c. protection of 400V on all ranges, but note that peak volts, that is d.c. + peak r.m.s., should not exceed 400V.

3.3 INPUT EARTH TERMINAL

The black terminal is connected to the instrument case and chassis and should normally be connected to the earth side of apparatus being tested. If this is not possible care should be taken to insulate the VM78 case from ground.

3.4 OVERLOAD PROTECTION

The instrument is fully protected against overload up to 400V peak on 0.3V and higher ranges, and 100V r.m.s. on 0.1V and lower ranges. On the upper ranges the method of protection is a d.c. blocking capacitor and attenuators. On the lower ranges the method of protection is by diode clamps. If the overload is applied for any length of time, a 60mA fuse F1 will blow. This can be easily replaced by removing the instrument from its case. A spare fuse will be found adjacent to the instrument fuse in use.

3.5 NON-SINUSOIDAL OPERATION

The instrument is an average responding device calibrated in terms of the r.m.s. value of a sine wave. When harmonics are present additional error is introduced in accordance with the following table:

Harmonic Content	*Error*
10% 2nd harmonic	+ 0.5%
20% 2nd harmonic	− 2%
50% 2nd harmonic	−10%
10% 3rd harmonic	± 4%
20% 3rd harmonic	± 8%
50% 3rd harmonic	−20% to +4%

3.6 DECIBEL MEASUREMENT

Set to the range required, bearing in mind the warning of para. 3.2. The range indicates the number of dB to be added to the meter reading using the −12dB to +2dB scale. For example, if the meter reads −10dB and the range is −40dB, the level is −50dB.

To read power directly in dBm the measurement must be made across 600 Ω (0dBm=1mW into 600 Ω).

3.7 USING SCREENED LEAD PL50

When measurements are made of low voltages across a high impedance source, hum or other pick-up signals may add to the voltage being measured. These effects can be avoided by using the screened lead PL50 supplied with the instrument. This lead will add approximately 60pF to the input capacity of 60pF.

If excessive shunt capacity is likely to cause errors, add a trimmer capacitor of 9pF in series with the input to form a capacity divider, thus reducing the input capacity and sensitivity by one tenth. The trimmer can be accurately calibrated by noting the reading of a low impedance r.f. signal generator on a given range without the trimmer. Connect and adjust the trimmer for the same reading with the range switch set for 20dB less attenuation.

4.1 GENERAL

By refering Fig. 1 to the circuit diagram, Fig. 4, it will be seen that the VM78 consists of three main sections, a high impedance stage, a two section attenuator and a directly coupled amplifier. The circuit description is therefore considered under these headings.

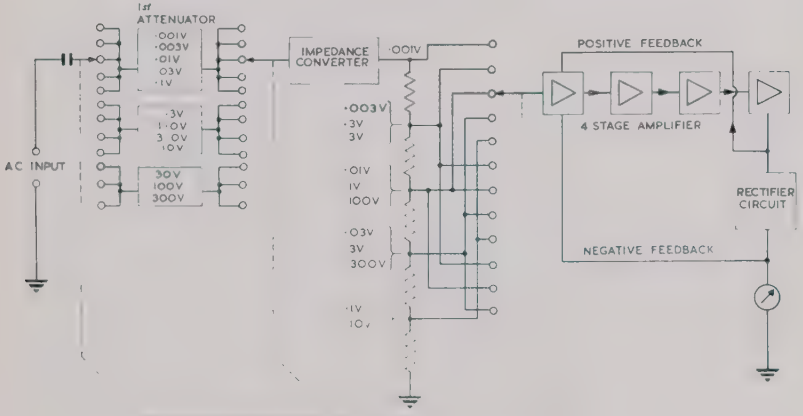

Fig. 1 Functional Diagram

4.2 HIGH IMPEDANCE INPUT

The high impedance input is basically two emitter followers TR1 and TR2 in cascade. Feedback is provided to the collector of TR1, via R15 and C12, to minimise the effect of base-collector impedance. Two diodes CR1 and CR2 are also used in the input circuit and give protection against overload by clamping the voltage swing at the base of TR1 to approximately ± 3V. The excess voltage swing is absorbed by R13. A 60mA fuse F1 in series with the input circuit will blow if large overload currents flow for more than a few seconds.

4.3 ATTENUATOR

The two section attenuator is arranged with a high impedance input section before the input stage and a low impedance section between the input stage and the main amplifier.

The two sections of the attenuator are arranged to work alternatively in the following sequence.

(a) Between 1mV and 0.1V the signal is applied directly to the high input impedance stage, and the low impedance section operates in five steps.

(b) Between 0.3V and 10V the signal is attenuated to one hundredth of its value before being directed to the input stage. The low impedance attenuator section then operates in four steps.

(c) Between 30V and 300V the signal is attenuated to one ten thousandth of its value before being directed to the input stage. The low impedance section then operates in three steps.

4.4 MAIN AMPLIFIER

The main high gain amplifier, which follows the low impedance section of the attenuator, is directly coupled in order to extend its frequency response down to 1 Hz. D.C. and a.c. feedback paths are arranged to keep the amplifier gain constant between 1 Hz and 1 MHz namely R30, R31; R35, R39 and via C18, C19.

The feedback and meter circuit time constants must necessarily be large for accurate measurements down to 1Hz. This means that several seconds must elapse after a voltage change before taking a reading off the meter. To avoid long delays, the function switch is arranged to switch out some of the circuit capacitance, if readings below 15 Hz are not required. The speed of response of the instrument is then correspondingly increased.

5.1 BATTERY REPLACEMENT

The mercury cells should be replaced when the voltage indicated on the meter falls to 7V. This may be easily carried out by removing the instrument from its case and unscrewing the battery cover. The position and polarity of the individual cells are shown on the top of the battery cover and in Fig. 2.

Note: The insulating tubing around the RM-3 cells should not be discarded, but should be fitted on the replacement cells before their insertion in the battery clip.

5.2 FUSE REPLACEMENT

The fuse F1 is accessible when the case is removed on the underside of the instrument as shown in fig. 3. A spare 60mA fuse is supplied in the clip adjacent to the normal fuse holder.

5.3 CALIBRATION PROCEDURE

(a) Setting Battery Test Voltage

With batteries removed, apply 12V d.c. across R45 with the negative potential at the junction of R45 and R46. Switch to the BAT. TEST position of the function switch and set the meter to read 8.2V by means of RV47.

(b) Setting TR7 Collector Voltage

Insert the complete set of batteries and place a shorting link across the input terminals. Set the range switch to 300V, and the function switch to the 15 Hz — 1 MHz position. Measure the voltage between earth and the collector of TR7 and set to 2.2V using RV36. Check that the voltage across R41 is approximately 0.6V.

(c) Check of Instrument Noise Level

With the shorting link still across the input terminals, set the range switch to the 1mV position. Check that the meter reading does not exceed 50μV. If an excessive reading is obtained, ensure that the fuse F1 is making a good low resistance contact with its clip. If an excessive reading still exists, the instrument should be returned to the factory for servicing.

Set the function switch to the 1 Hz — 1 MHz position and allow approximately 1½ min. for the instrument to stabilise. Check that the meter reading again does not exceed 50μV. In the case of an excessive reading, refer to the preceding sub-paragraph.

(d) Adjustment of Overall Gain (3mV range)

Set the range switch to the 3mV position. Apply an input signal of 3mV at 1 kHz and adjust RV44 for a full scale reading on the meter.

(e) Adjustment of Input Capacity

With the shorting link removed, connect the input terminals to a Q meter, such as the Advance Q meter T2, and set the VM78 on the 10mV range. Set the Q meter internal capacitor to a minimum. Plug in any suitable coil and resonate by adjusting the Q meter test frequency in the range 200 kHz to 3 MHz.

On the VM78, set to the 10V range and adjust C29 to obtain resonance, using an insulated trimmer.
Switch to the 100V range and similarly adjust C30.

(f) Attenuator Alignment

(i) Set the function switch to the 15 Hz to 1 MHz position and apply an input signal of 1 kHz from a low impedance source. Make adjustments for f.s.d. as follows:

Input Level	*Range*	*Adjust*
0.3V	0.3V	RV3
30V	30V	RV9

(ii) Apply an input signal of 1 MHz from a low impedance source and make adjustments for f.s.d. as follows:

Input Level	*Range*	*Adjust*
3mV	3mV	C28
30mV	30mV	C13
100mV	100mV	C14
3V	3V	C2
30V	30V	C4

(iii) On the 30V range with an input of 30V, check that the meter accuracy at 600 kHz and 1 MHz is within $\pm 3\%$. If the reading at 600 kHz is high, adjust RV57 to obtain the required accuracy. Access to RV57 is possible, when the case is removed, by releasing one screw holding the printed board at the rear, and by removing the square screening can which is held in position by two screws. RV57 will be found immediately adjacent to the range switch.

(iv) Check through the whole or part of the calibration procedure as required.

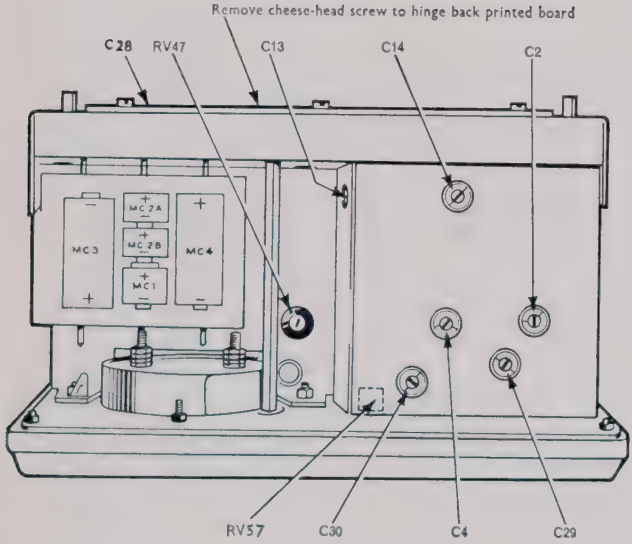

Fig. 2
Upper Chassis View

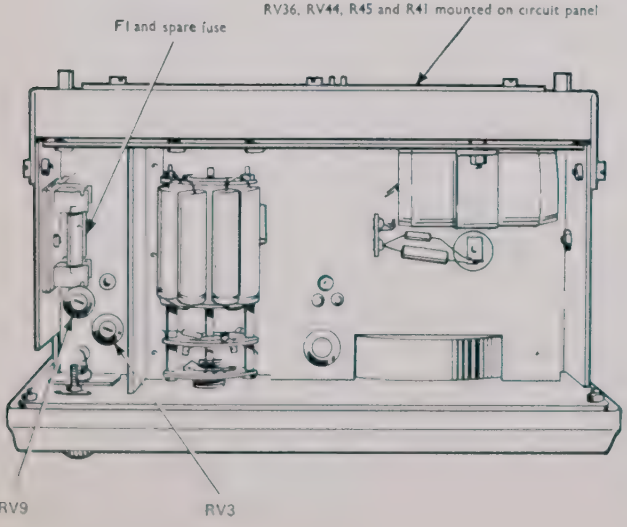

Fig. 3
Under Chassis View

RESISTORS (5% Erie 16 unless specified)

Ref.	Value	Description	Part No.
R1	2M	1% RRC 2HS2	1724
R2	19·6K	1% RRC 2HS2	1725
RV3	2·2K	Plessey MPD (adjust 0·3V range LF)	1756
R4	2M	1% RRC 2HS2	1724
R5	221	1% RRC 2HS2	11502
R6	2·7	5% RRC 2HS2	1726
R7	(not used)		
R8	1·5K	1% RRC 2HS2	11498
RV9	2·2K	Plessey MPD (adjust 30V range LF)	1756
R10	10M	(adjust on test)	1179
R11	120K		4407
R12	120K	10%	4407
R13	1K	2% RRC N.25	1993
R14	5·6K		3428
R15	1·2K		1172
R16	15K		3430
R17	68K		7296
R18	4·7K		3427
R19A	3419	½% Welwyn M81	1853
R19B	1081	½% Welwyn M81	1854
R19C	341·9	½% Welwyn M81	1855
R19D	108·1	½% Welwyn M81	1856
R19E	51	5% RRC 5SWD (adjust on test)	11511
R20	1080	1% RRC 2HS2	1727
R21	634	1% RRC 2HS2	1728
R22	920	1% RRC 2HS2	1729
R23	1030	1% RRC 2HS2	1730
R24	15K		3430
R25	56K		3435
R26	27K		868
R27	4·7K		3427
R28	3·3K		3425
R29	5·6K		3428
R30	47K		2933
R31	47K		2933
R32	180		1815
R33	1·5K		4405
R34	4·7K		3427
R35	15K		3430
RV36	22K	Plessey MPD (adjust Vc TR7)	1757
R37	4·7K		3427
R38	390		612
R39	15K		3430
R40	3·3K		3430
R41	680		7497
R42	100	(adjust overall gain 3mV range)	3416
R43	(not used)		
RV44	50	Egen 195	1858
R45	2·7K		3247
R46	120K		4407
RV47	56K	Plessey MPD (battery test adjustment)	1758
R48	180	Erie 8 (former of L2)	21295
R49	150K		3436
R50	4·7K		3427
R51	5·6K		3428
R52	100		3416
R53	37·35	1% RRC 2HS2	1860
R54	180	1% RRC 2HS2	1861
R55	30	1% RRC 2HS2	1862
R56	6·8K	(adjust on test)	6319
RV57	10	Egen 195	12933

CAPACITORS (Wima Printilyt unless specified)

Ref.	Value	Description	Part No.
C1	0·47	400V Mullard C296 AC/A 470K	1740
C2	2 to 8p	trimmer Triko 10 BM D20 (adjust 0·3V range HF)	11495
C3	560p	20% Erie Ceramicon HI-K AD K120051	329
C4	2 to 8p	trimmer Triko 10 BM D20 (adjust 30V range HF)	11495
C5	0·033	10% Mullard C296 AA/A	790
C7	4	70V Electrolytic Plessey CE 1204	1741
C8	10p	Lemco S/M 10% 500V 1510 Insul.	2677
C9	500	3V	1742
C10	250	6V	1743
C11	100	12V	1744
C12	10	30V	1745
C13	1·5 to 60p	trimmer Mullard C010 AA/60E (adjust 30mVrange HF)	1866
C14	1·5 to 60p	trimmer Mullard C010 AA/60E (adjust 100mV range HF)	1866
C15	100	12V	1744
C16	500	3V	1742
C17	2000	12V Plessey CE 1237/1	1864
C18	250	6V	1743
C19	50	6V	1746
C20	100	12V	1744
C21	250	6V	1743
C22	250	6V	1743
C23	50	6V	1746
C24	50	6V	1746
C25	250	6V	1743
C26	250	6V	1743

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R28	3·3K		3425
R29	5·6K		3428
R30	47K		2933
R31	47K		2933
R32	180		1815
R33	1·5K		4405
R34	4·7K		3427
R35	15K		3430
RV36	22K	Plessey MPD (adjust Vc TR7)	1757
R37	4·7K		3427
R38	390		612
R39	15K		3430
R40	3·3K		3430
R41	680		7497
R42	100	(adjust overall gain 3mV range)	3416
R43	(not used)		
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R45	2·7K		3247
R46	120K		4407
RV47	56K	Plessey MPD (battery test adjustment)	1758
R48	180	Erie 8 (former of L2)	21295
R49	150K		3436
R50	4·7K		3427
R51	5·6K		3428
R52	100		3416
R53	37·35	1% RRC 2HS2	1860
R54	180	1% RRC 2HS2	1861
R55	30	1% RRC 2HS2	1862
R56	6·8K	(adjust on test)	6319
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C7	4	70V Electrolytic Plessey CE 1204	1741
C8	10p	Lemco S/M 10% 500V 1510 Insul.	2677
C9	500	3V	1742
C10	250	6V	1743
C11	100	12V	1744
C12	10	30V	1745
C13	1·5 to 60p	trimmer Mullard C010 AA/60E (adjust 30mVrange HF)	1866
C14	1·5 to 60p	trimmer Mullard C010 AA/60E (adjust 100mV range HF)	1866
C15	100	12V	1744
C16	500	3V	1742
C17	2000	12V Plessey CE 1237/1	1864
C18	250	6V	1743
C19	50	6V	1746
C20	100	12V	1744
C21	250	6V	1743
C22	250	6V	1743
C23	50	6V	1746
C24	50	6V	1746
C25	250	6V	1743
C26	250	6V	1743

CAPACITORS continued

Ref.	Value	Description	Part No.
C27	100p	5% Lemco S/M 350V 1106 Insul. (adjust on test)	11675
C28	140p	trimmer Cyldon MT 31A/5	1738
C29	6 to 30p	trimmer 004A/10B/D50	2097
C30	6 to 30p	trimmer 004a/10B/D50	2097

TRANSISTORS

TR1	GET889	Mullard (selected)	3607
TR2	OC170	Mullard	1557
TR3	V205	Fairchild (selected)	3307
TR4	V205	Fairchild (selected)	3307
TR5	OC139	Mullard	1067
TR6	OC170	Mullard	1557
TR7	OC170	Mullard	1557

DIODES

CR1	OA200	Mullard	1874
CR2	OA200	Mullard	1874
CR3	IS916	Texas	1949
CR4	IS916	Texas	1949

SWITCHES

SW1	Range Switch	1754
SW2	Function Switch	1873

BATTERIES

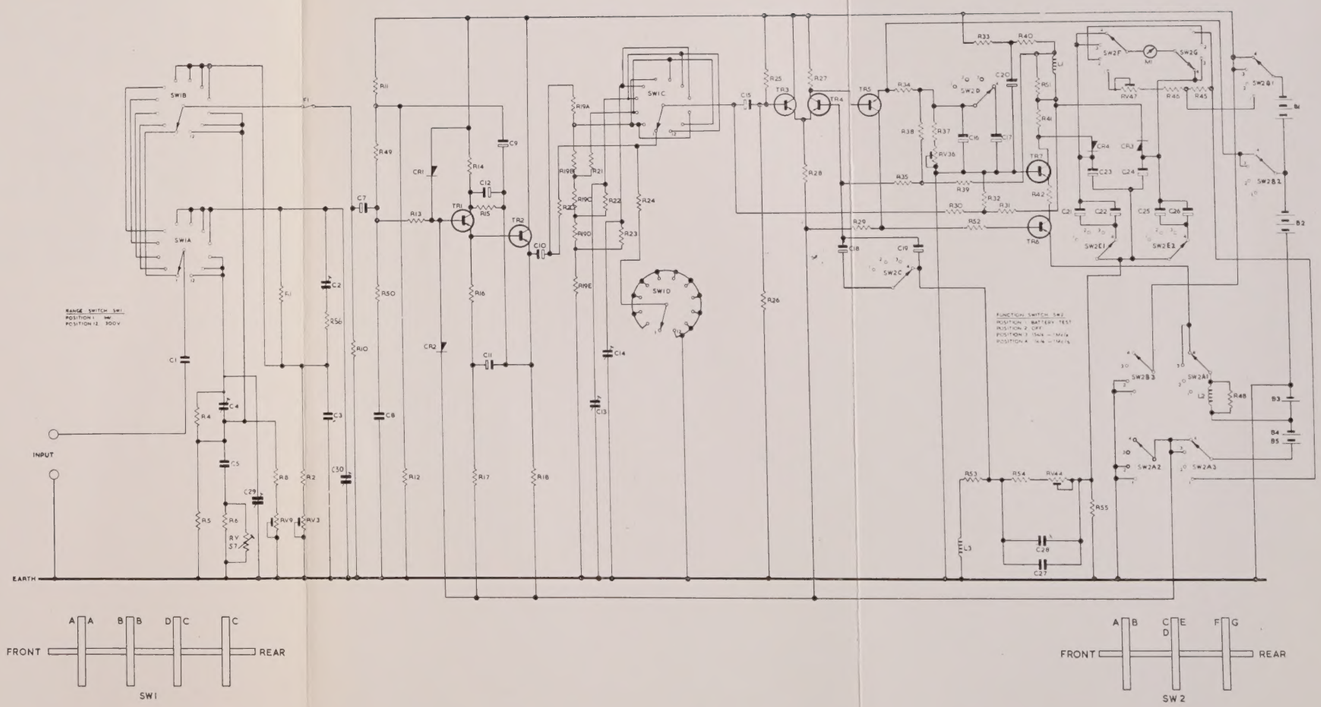
B1	4V	Mercury Mallory TR-233R	1761
B2	4V	Mercury Mallory TR-233R	1761
B3	1·34V	Mercury Mallory RM-3	1760
B4	1·34V	Mercury Mallory RM-3	1760
B5	1·34V	Mercury Mallory RM-3	1760

CHOKES

L1	1mH	C153
L2	6·8μH	C202
L3	1μH	C154

MISCELLANEOUS

M1	100μA FSD 5000Ω		15026
F1	60mA Belling Lee L1055		1759



The right is reserved to amend values or alter the circuit without notice

Fig. 4 Circuit Diagram

Guarantee and Service Facilities *Section 7*

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than valves, semiconductors and fuses. Valves and semiconductors are subject to the manufacturers' guarantee.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The Type and Serial Number of the instrument should always be quoted, together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with transportation charges prepaid. We can accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired, the repair will be put in hand without delay and charged unless other instructions are received.

OUR SALES, SERVICE AND ENGINEERING DEPARTMENTS ARE READY TO ASSIST YOU AT ALL TIMES.

Manual Part No. 1952

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